HABITAT MANAGEMENT GUIDELINES FOR AMPHIBIANS AND REPTILES OF THE NORTHEASTERN UNITED STATES

Working Draft Current as of 1 September 2003

Partners page (inside front cover; need partner logos)

This booklet is the product of extensive efforts of many people and contains the contributions of many individuals from academic, private, government, and industrial backgrounds. The Acknowledgments section at the end of this booklet contains a list of all those who have helped with text, photos, and production. Lead writer for this book was Joseph C. Mitchell, a conservation biologist and herpetologist with the University of Richmond in Virginia. Mitchell is the co-chair of the Management Working Group and the PARC Steering Committee.

This Habitat Management Guidelines booklet is a production of Partners in Amphibian and Reptile Conservation (PARC). PARC's mission is "to conserve amphibians, reptiles, and their habitats as integral parts of our ecosystem and culture through proactive and coordinated public/private partnerships." The emphasis is on partnerships, as we are seeking to work with everyone to find solutions to common issues. PARC is not a funding or government agency. It does not create or dictate policy. Rather, it provides recommendations and guidelines based on sound science. It is intended to increase communication and cooperation with many diverse groups who have a common interest in amphibians, reptiles, and their habitats. Through documents such as this, PARC will give individuals a better idea of how they or their agencies, companies, or organization can contribute to the conservation and management of habitats on the landscape. The diversity of partners makes PARC the most comprehensive conservation effort ever undertaken for these two groups of wildlife. At the core of PARC is the philosophy is that we all must work together. There is no "us versus them." It is all "us." If you want to find out more about PARC, please visit our web site at: http://www.parcplace.org. Thank you.

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Preface

Amphibians and reptiles are in trouble. The public now recognizes that many of these animals have declined in abundance and that their distribution across the landscape has been reduced. Malformed amphibians have generated much media attention because they are telling us that something is going wrong in our environment. Are they telling us something that may eventually affect humans? To address the alarming declines and concerns, the Partners for Amphibian and Reptile Conservation (PARC) Management Working Group developed collaboratively-derived, scientifically-based Habitat Management Guidelines (HMGs) for native amphibians and reptiles in the Northeast region (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia). The goal of this project is to use the best science and professional experience available to produce guidelines that are easily understood and applied by land managers and private land owners.

When applied on the ground as general management principles, these guidelines will:

- Help keep common species common.
- Help stem the decline of imperiled species.
- Guide the restoration of habitats containing amphibians and reptiles previously degraded or destroyed.
- Reduce the chances that additional species will be added to endangered species lists.

Conservation needs for North American amphibian and reptiles were identified at the first (PARC) meeting, held in Atlanta, Georgia in June 1999. PARC partners recognized that effective *Habitat Conservation Guidelines* for amphibians and reptiles could be developed for land owners and land managers. The idea was to create several colorful, photo-filled publications, each specific to one of five general regions of the United States. Each of these would identify the important habitats used by amphibian and reptiles and present land owners and land managers with options for improving or at least considering the well-being of these creatures in their management activities. Therefore, the target audience is the land owners and the public/private land managers who are engaged in land management in a specific region and may wish or be willing to include amphibians and reptiles in their land management strategies.

We hope to show landowners and land managers how implementing the guidelines in these products are beneficial to them. PARC believes that implementing the guidelines will provide landscapes and their wildlife benefits beyond amphibian and reptile conservation. PARC hopes that implementing some of these guidelines will diminish the likelihood of additional species being added to state and federal endangered species lists. This is simply preventative maintenance.

We have not created a document which describes the needs of every species of amphibian and reptile. Instead, we provide guidelines for managing *habitats* in each region in ways that have general positive benefits for the associated species. Quite frankly, amphibian and reptile populations are declining in the United States and will continue to do so as human populations and associated development continue to expand. These guidelines are not regulations, nor are they in any way an attempt to limit land owners rights. They can be regarded simply as pleas from the PARC community for land owners and managers to consider the needs of amphibians and reptiles in the course of their land management activities.

How to Use These Guidelines

1. First identify the habitat type on which you need to focus.

2. Gain an understanding of which species are likely to occur and live in that habitat.

3. Review the recommended guidelines for that habitat type and determine if they will work on your land.

5. Work with regional experts to determine which guidelines are best and which ones need modification so that they will work on your land.

6. Implement the guidelines you have selected.

7. Conduct follow-up evaluations to determine if the guidelines worked. If they do, then continue to use this approach. If they do not, then reevaluate the guidelines to determine where the problem is located.

Conduct follow-up evaluations to determine if the guidelines worked. If they do, then continue to use this approach. If they do not, then reevaluate the guidelines to locate the problem.

Each of the habitat sections contains three sets of guidelines. The first is for landowners/ managers who wish to make amphibian and reptile conservation a *primary* objective ("**Ideal**"). The second is for those seeking to minimize impacts to these animals while managing the land for other uses, such as timber, recreation, grazing, development, agriculture, etc. ("**Compatible**"). Examples of **Incompatible** management are provided where appropriate.

Depending on site conditions, habitat *Protection, Enhancement, Restoration,* and *Creation* are important management strategies to consider. Definitions are as follows:

Protection: Protect what you have (i.e., natural areas) from loss and degradation. Protection of key areas differs from preservation of an entire property in its natural state. Preservation may be an option for public lands and non-government organizations, and it may be feasible for private landowners and industry.

Enhancement: Improve a particular habitat for the amphibians and reptiles that should be present or was natural in historical times. Enhancement may be considered a step toward restoration in some cases.

Restoration: Using enhancement techniques, restore degraded habitats back to naturally functional habitats (e.g., ditched wetland to vernal pool with natural hydroperiod, early successional forest to old growth).

Creation: To provide suitable habitat (e.g., wetlands) where none existed before or has not existed in a long time.

Introduction

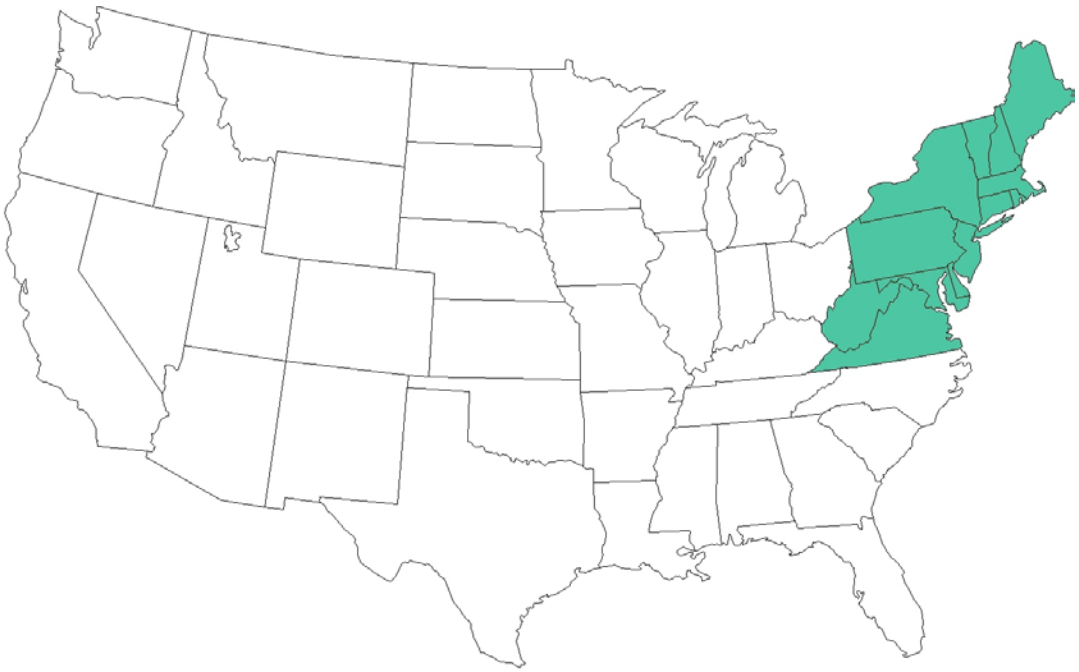
Natural resource management has traditionally focused on single species, although recently more emphasis has been placed on management of habitats. Although management of single species can be successful, it ignores those with which a single species interacts directly or indirectly. Ecosystem management approaches the issue from a more holistic perspective by focusing on integrated natural systems at some landscape scale (e.g., community type, watershed). Effective management for amphibians and reptiles lies somewhere in-between these two approaches. These animals are usually secretive, may occur in large numbers, use both aquatic and terrestrial habitats, and lie dormant during periods of cold and drought. Most do not move long distances but some disperse several kilometers. Populations interact with the local landscape and habitat mosaic more than they do at the ecosystem scale, although some species are tied closely to some ecosystems. Effective management for these animals is thus best approached from a habitat perspective.

Management guidelines in this document have been derived from an extensive body of information on amphibians and reptiles. This document uses much of this information to provide the basis for the habitat management guidelines we present. These guidelines are meant to be general so that their actual applications can be tailor-made to the location or habitat of interest.

The target audience is the land owner and land manager. These individuals are engaged in managing their own property or a specific site owned by public or private entities. Implementation of these guidelines will result in a broader view of the natural area and long term conservation of these vertebrates. Such an approach to habitat conservation and management will decrease the probability that some species will be listed as endangered or threatened.

Amphibians and Reptiles of the Northeast

The Northeast region of the United States supports at least 000 species amphibians and 000 species of reptiles. A complete list of species by scientific name and common name (following Crother, 2000. Scientific and Common Names Checklist. Society for the Study of Amphibians and Reptiles. Herp. Circ. 29), along with their occurrence by state and habitats as used in this guide, is in Appendix A.



The Northeast region of PARC includes the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia. Note that amphibians and reptiles in this region do not adhere to state boundaries, thus the Habitat Management Guidelines in this document are applicable to some extent to the bordering states as well.

Ecoregions of the Northeast

The 13 states covered in this document span 12 ecoregions, as defined by The Nature Conservancy (Figure 1). Ecoregions are presented here to help you orient to where various habitats are located. They will be referred to frequently in the text. Keep in mind that one habitat type may occur in several ecoregions. For example, seasonal wetlands occur in all of the ecoregions of the Northeast, whereas caves and karst habitats occur in one or two ecoregions. The line separating the flat Coastal Plain from the geologically older Piedmont and mountainous regions is the Fall Line. This geological feature influences the distributions of many species.

48 Great Lakes
49 Western Allegheny Plateau
50 Cumberland and Southern Ridge and Valley
51 Southern Blue Ridge
52 Piedmont
58 Chesapeake Bay Lowlands
59 Central Appalachian Forest
60 High Allegheny Plateau
61 Lower New England/Northern Piedmont
62 North Atlantic Coast
63 Northern Appalachian-Boreal Forest
64 St. Lawrence-Champlain Valley

Figure 1. Ecoregions of the Northeast. Modified from The Nature Conservancy.

Mark Bailey agreed to supply the map.

Natural History of Amphibians and Reptiles

Amphibians and reptiles (herps from the branch of science called herpetology) are vertebrates like birds and mammals, but they are fundamentally different in one very important way. Herps are "cold bloodied," whereas birds and mammals are "warm bloodied." This means that the source of body heat is external for herps and internal for the other two groups. Why is this important? Being warm bloodied (= endothermy) requires these animals to eat regularly to nearly constantly to fuel the biochemical mechanisms producing body heat. Most are therefore active year-round or nearly so.

Not so with herps. Because body heat derives from external sources (= ectothermy), these animals do not need to feed regularly and can be inactive for periods of time. Some large snakes, for example, need only one large meal per year. Terrestrial salamanders feed primarily on several warm, wet nights during their active season. Given a few exceptions, herps are inactive during cold periods and most are inactive when environmental conditions are dry. They do not have protective covers of feathers or fur, so most must stay moist to survive. Thus, the combined conditions of temperature and moisture regulate when and where amphibians and reptiles are active. This, in turn, greatly affects when and where we see them actively moving about or basking. Spadefoot toads, for example, may stay buried in ground for several years before they appear during or following heavy rainfall.

Herps are rarely confined to a single habitat. Most use many habitats during the course of a single year and throughout their lives. Many frogs and some salamanders in the Northeast breed for weeks to months in ponds or vernal pools but otherwise spend the rest of their lives in the terrestrial environment, usually in association with hardwood forests. Many of the freshwater turtles live in ponds and lakes but lay eggs on land and often spent long periods buried in the substrate. Movement between habitats like ponds and forests occurs in many cases over distances of several hundred meters or more. During movements across the landscape herps may encounter roads or other human-made structures. Many are barriers or death traps, and numerous herps are killed on roads annually. Such features of the landscape should be kept in mind when managing habitats for these animals.

Amphibians are considered sensitive environmental indicators because they produce unshelled eggs that must be in water or kept moist, have moist skin across which chemicals can enter their bodies, and start out first as aquatic frog tadpoles or salamander larvae. Each individual thus encounters and must survive chemicals in water, on land, and in the air throughout its lifetime. Habitats that have harmful substances may not support amphibian populations no matter how healthy the habitat is otherwise.

Reptiles on the other hand, lay shelled eggs or produce offspring via live birth, and scales serve as a protective barrier to moisture loss and take-up of chemicals. Thus, they are able to exist in drier habitats than most amphibians. Eggs must be laid in moist microhabitats, however, and no reptile can withstand long periods without water. Indeed, most are active when conditions are moist (e.g., during rainfall or high humidity) and stay concealed when it is dry.

Both groups play important roles in their habitats both as predators of other animals or as prey. The prey they eat serve as sources of energy or harmful chemicals that can be passed on to offspring or to predators. Some amphibians and reptiles prey on each other. They are major links

in the flow of energy from aquatic to terrestrial systems (e.g., through amphibian metamorphosis or aquatic reptiles laying eggs on land).

The 00 frog species, 00 salamanders, 00 turtles, 00 lizards, and 00 snakes that occur in the Northeast illustrate a range of life histories and adaptations to various habitats in the region. Understanding their basic natural history is essential to effective management of their habitats and populations. Sources of information on herps in the Northeast are included in the list of resources at the end of this guide.

NEED PHOTOS OF EXAMPLE FROG, SALAMANDER, TURTLE, LIZARD, SNAKE THAT ILLUSTRATE SOME OF THEIR NATURAL HISTORY

Threats to Amphibians and Reptiles

Amphibians and reptiles in the Northeast are threatened by a host of factors, most of which are human-caused. Most species have lost habitats and experienced losses of populations since European colonization nearly 400 years ago. This mini-review provides the backdrop for land owners and managers to understand why biologists, naturalists, and herpetologists are concerned about these animals.

Habitat Loss and Fragmentation

Habitat loss is alteration of the landscape that results in elimination of the original natural habitat. Habitat fragmentation is a consequence of habitat loss that results in isolated patches of original habitat.

Naturalists, scientists, and land managers agree that ***local habitat destruction and loss*** is the primary cause of reptile and amphibian declines in the Northeast. Activities such as agriculture, silviculture, building industrial complexes, urbanization, road building, stream channelization, filling and draining wetlands and creation of impoundments are examples of habitat loss and alteration.

The size of the original habitat fragment, distances to other fragments containing populations, and barriers to dispersal in zones between fragments all set up a suite of factors that affect whether an amphibian or reptile population remains viable. Small population size has inbreeding and other genetic problems. They are more vulnerable to single catastrophic events such as extreme weather or disease outbreaks. Simply finding one another for mating and production of the next generation is a challenge due to dispersal and migration barriers across expanses of inhospitable habitats.

Because most amphibians and reptiles use more than one habitat daily or seasonally, it is intuitively simple to realize that small habitat patches seldom support viable populations. These animals must be able to move from one fragment to another and survive the gauntlet between them during their travels. The challenge to do in much of the Northeast is daunting to most of these animals.

Landscape Scale and Connectivity

Landscape scale is the geographic scale of the management area in question and includes all the interactive habitats in that area. This can be an entire watershed or the land within the political boundaries of an area under management. Landscape matrix refers to the complex of different habitat types, including the altered or unsuitable land between intact habitat fragments. Viewed from the animal's perspective, the matrix includes all the barriers and sources of mortality in the gauntlet through which they must move in order to disperse between habitats.

Integrating a **Landscape Approach** into your **Management Plan** will greatly enhance the long-term persistence of amphibians and reptiles. These animals use uplands and wetlands in complex ways and move extensively among them. They have highly seasonal activity patterns that are

tied to their use of these two primary habitat types. Understanding the natural history of these animals, their seasonal movements between habitats, and the natural dynamics of the habitats themselves is crucial for management at the landscape level. The traditional concept of "buffering" streams with narrow strips of wooded uplands, for example, is usually inadequate and will do little to prevent population declines.

Think landscape scale and landscape matrix. Most amphibians and reptiles require two or more habitats during their lifetimes for reproduction, foraging, hibernating, etc. Habitat use changes seasonally due to reproductive and foraging behavior, and it may change annually as individuals shift areas that they use over time. Integrate the concepts of multiple habitats, their juxtaposition to one another, and the types of habitat or altered habitats between them into your vision of how to manage your land. These are what amphibians and reptiles face on your land. Think like them.

Therefore, the buffered habitat, the "buffer zone" habitat, and the gradient between the two are all critical to the survival of reptile and amphibian populations. *So* think "matrix" "landscape scale," and consider all possible "complementary habitats" when creating management plans. For example, how much upland habitat is needed for non-breeding activities by species that breed in wetlands (streams, isolated wetlands)? How much lowland foraging habitat is needed by species that hibernate or nest in adjacent uplands long distances away?

Think connectivity. Through what habitats would amphibians and reptiles move when migrating from one area to another? Establishment of corridors and patches of suitable habitat that enhance survival during migration and movement is essential for the conservation of most species in northeastern habitats. How much upland habitat is needed for the non-breeding activities of species that breed in wetlands (isolated wetlands, streams)?

Think impacts. How do various human activities impact each habitat type on your land? Knowing how such activities may impact these habitats and what it takes to manage them in a natural state will provide valuable insights into how to manage your landscape. Such an approach, some of it intuitive, will help to ensure that the amphibian and reptile populations on your land will remain healthy. A well thought out Management Plan with all of these aspects and goals in mind will greatly enhance success.

Roads

Roads include all corridors of paved, gravel, or dirt surfaces on which vehicles move across the landscape. There are 0000 miles of "improved" roads in the Northeast on which thousands, if not hundreds of thousands, of amphibians and reptiles are killed annually.

Roads through natural habitats set the stage for high rates of mortality of most forms of wildlife, including amphibians and reptiles, by death from vehicles. Many herps are killed during migrations to and from breeding sites, to and from hibernacula and summer foraging areas, and during searching for mates. Roads also harm aquatic species by contributing to pollution of streams and wetlands via runoff of chemicals, including salts applied during periods of snow. Roads allow human access to rural landscapes causing increased land development, habitat

loss, and vulnerability to exploitation. Newly opened corridors create habitat for edge-adapted vegetation (including exotic plants); roads change interior habitat to edge habitat. Edge habitats change favorable conditions to unfavorable environments and allow invasion by subsidized predators.

Consider the following:

- New road construction should be avoided if at all possible, especially in rural areas.
- Restricting access by gating non-essential roads can be effective and is easily accomplished on some public and private lands. Closing roads temporarily during breeding migrations can be an effective management tool.
- Reducing speed limits and adding cautionary signage may encourage motorists to avoid hitting migrating herpetofauna and other animals.
- A combination of directional fencing and underpasses (ecopassages) can be used in some cases to funnel wildlife safely from one side of a roadway to the other.
    - Passageways should be located in existing migration routes, such as where a road separates breeding from non-breeding habitat.
    - When planning, designing, and building wildlife crossings, ensure the future viability of habitat on either side through land acquisition or easements.
- Minimize the number of roads across which amphibians and reptiles must cross in the landscape under management.
- Review the effects of logging roads on your land. Even temporary unpaved roads can cause increases in mortality and allow introduction of undesirable species. Consider alternative logging methods.

Exploitation

Exploitation is the removal of individual amphibians and reptiles from their native habitats for commercial benefit to individual humans.

Exploitation comes in many varieties. Commercial trade in live amphibians and reptiles and their skins is a multimillion business annually. Although most states in the Northeast have laws regulating commercial take of these animals, many are in fact removed from natural populations for the pet trade and increasingly for the food market in foreign countries. Laws protecting amphibians and reptiles vary from state to state and enforcement is often lax where adequate laws exist. Box turtle, wood turtles, some snakes, and some frogs and salamanders are still being collected and sold. Freshwater turtles are under increasing pressure from collectors for the

oriental food markets. People still kill snakes and other herpetofauna due to fear, hatred, and ignorance. People still remove animals, especially turtles, from state and national parks and recreation areas.

Increased awareness through education has indeed caused a modest shift in human attitudes towards these animals. However, hunters, fishermen, hikers, loggers, farmers, and others who interact regularly with the outdoors are seldom provided with herpetofaunal-specific education opportunities or information.

What Can Land Managers Do?

- Prohibit recreational and commercial visitors from harming amphibians, reptiles, and habitats.
- Provide recreational and commercial visitors with herpetofauna-specific educational opportunities and materials.
- Encourage enforcement agencies to patrol your land for possible violators of state and federal laws and local ordinances.

Chemicals

Herbicides are chemicals used to kill or alter growth of plants. Pesticides are chemicals used to kill pest animals. Fertilizers are chemicals used to enhance plant growth.

A suite of chemicals is introduced into the landscape and natural habitats routinely, if not daily. A growing number of scientific studies are showing that chemicals, such as fertilizers that were formerly considered benign, cause mortality, reproductive malformations, and abnormalities in amphibians and reptiles. Pesticides and other chemicals are well known to cause these problems. Some of them, such as organophosphates and PCBs, accumulate in body tissues and reach concentrations many times that considered safe. Consumption of some reptiles, like the snapping turtle, that have high toxic levels may cause health problems in humans. In addition to occasionally being toxic directly to reptiles and amphibians (aquatic species in particular), pesticides, herbicides, and fertilizers also damage habitats and food resources.

Pesticides may eliminate important invertebrate prey species for herps, as well as birds, bats, and other mammals. Herbicides may destroy valuable herbaceous abundance and diversity, lowering prey populations and, ultimately, starving predatory fauna, including amphibians and reptiles. If used near aquatic systems, fertilizers may feed excessive algae blooms, which alter dissolved oxygen and CO_2 levels sometimes causing mortality of herps and their prey.

What Can Land Managers Do?

- Know the effects of the herbicides and pesticides used on your land. FOLLOW INSTRUCTIONS ON THE CONTAINER LABELS.

- Use plants that require minimal chemicals and seek ways to implement bio-control measures.

Fire Suppression

Prescribed fire is a tool used by land managers to alter forest or grassland habitats in such a way as to remove undesirable or introduced vegetation and stimulate natural growth of the native plants and to maintain a natural ecosystem.

Fire was a natural part of Northeastern forests long before modern timber management and control of fire. Depending on regional drought cycles, lightning-sparked fires would burn for weeks or months. Native Americans would also set fires to clear undergrowth and stimulate herbaceous growth. Rivers, large streams, and some wetlands served as natural firebreaks. As a result, many reptiles and amphibians, their habitats, and their prey are tolerant of or even dependent on fire and its effects on habitats. Amphibians and reptiles in parts of the Cumberland and Southern Ridge and Valley, Southern Blue Ridge, Piedmont, Central Appalachian Forest, High Allegheny Plateau, and Lower New England/Northern Piedmont ecoregions were adapted to open woodlands interspersed with grasslands and balds.

Prescribed or controlled fires are used in modern habitat management to eliminate undesirable plants and to help stimulate growth of desirable species. Such fires also reduce fuel supplies for unplanned wildfires which can cause property damage and loss of life. Fires also increase land value by enhancing game habitat and timber potential.

Most of our terrestrial ecosystems have burned occasionally throughout history. Some habitats, like the Pine Barrens, require fire for forest health. Even wetlands and swamps burned during times of extreme drought. The ideal frequency, intensity, and seasonality of prescribed fire is highly variable depending on climate, slope, aspect, elevation, soil characteristics, and moisture retention capacity of native vegetation.

What Can Land Managers Do?

- Determine the natural historic fire frequency in your region. This can be a challenge and may require information from fire ecologists in your area.

- Determine if prescribed fire is possible on your land given state and local fire ordinances.

- Work with forest and wildlife biologists and qualified fire ecologists who can help work though the many issues of fire management. Confer with a regional herpetologist who knows activity patterns and habitat use of local amphibians and reptiles to determine when fires would cause the least mortality.

CAUTION! Excessive or poorly planned fires can do more harm than good. Before you strike a match, consult a qualified ecologist for information on when, where, and how to burn, as well as when, where, and how NOT to burn.

Introduced Species

Introduced species are those that are not native to the Northeast and have been brought into this region deliberately, like the gypsy moth and English sparrow, or inadvertently, like the chestnut blight and Asian long-horned beetle. They usually cause ecological, economic, and health problems.

Introduced (exotic) species, once they become established, find no predators or other organisms that limit their numbers. Thus, they usually reach larger population sizes that overwhelm native populations and species in dramatic ways. The most successful (and threatening) exotics are highly adaptable, rapidly-reproducing habitat generalists that can quickly overwhelm, displace, and even extirpate native species and communities. Purple loosestrife, a plant introduced from 00000000000, has choked wetlands and reduced habitat for reptiles like the endangered bog turtle. The chestnut blight that wiped out an entire dominant hardwood tree in the Appalachians almost certainly affected woodland salamanders by the elimination of a prime source of woody debris and hibernacula in stump holes. Domestic free-ranging and feral cats, introduced in the 1600s, kill thousands of amphibians and reptiles annually.

What Can Land Managers Do?

- Where game plots are needed, use native browse.
- Plant native grasses as erosion control.
- Avoid the introduction of non-native wildlife species on game ranches.
- Avoid the introduction of timber species beyond their native range.
- Where exotic species are already established, consult a qualified invasive species specialist for the safest, most effective means of eradicating exotic populations.
- Control or eliminate feral cat populations and keep the house cat indoors.

Subsidized Predators

Subsidized predators are native species whose populations have increased in parts of their range due to resources provided directly or indirectly by humans.

The subsidized predators best known to kill amphibians and reptiles are raccoons, Virginia opossum, foxes, crows, and ravens. These animals, especially the raccoon, are well-known predators of adult turtles and eggs in their nests. Studies have documented 100% mortality of eggs in all nests in some painted turtle populations by this predator. Crows and foxed have been observed to eat eggs as they were dropped into nest holes by female turtles. These predators also kill and eat frogs, small snakes, and lizards. Populations of subsidized predators are uncontrolled in urban areas and in places like state and national parks.

What Can Land Managers Do?

- Control subsidized predator populations by reduction in the subsidies (refuges, food sources) or by removal of individuals.
- Consider that subsidized predators are not likely at natural population levels in some areas. Thus, evaluations of their behavior, effects, population sizes, and sources of subsidy could help identify ways to curb their impact on native amphibians and reptiles.

Habitats Important to Amphibians and Reptiles

We identified five aquatic and seven terrestrial habitats in the Northeast that are intuitively distinct from each other and can be associated with assemblages of amphibians and reptiles that characterize these habitats. Very few species of either group occur exclusively in any one habitat type, however. Many species occupy several and in some cases most of these habitat types.

Aquatic habitats include

A. Seasonal wetlands
B. Permanent wetlands
C. Streams
D. Rivers
E. Estuarine/marine

Terrestrial habitats include

F. Mesic upland forests
G. Spruce/fir forests
H. Xeric upland forests
I. Grasslands/old fields
J. Rock outcrops/talus
K. Caves/karst
L. Agricultural
M. Urban

A. Seasonal Wetlands

Seasonal wetlands include isolated depressions in the landscape (sinkhole ponds, vernal pools, low swales, road ruts) that hold water in winter and spring but usually dry by mid-summer or fall. There are no connections to flowing water and fish are usually absent. Vernal pools in riparian floodplains may contain fish periodically. Seasonal wetlands are critical breeding habitats for many amphibians, especially those vulnerable to fish predation, some reptiles, and many invertebrates. Water sources are rainfall, elevated water tables, or flooding in floodplain pools. Vegetation in these wetlands depends on soil type, hydroperiod, latitude, elevation, and past land use. Seasonal wetlands in areas with no or sparse forest canopies support herbaceous plants, including grasses, sedges, and rushes. Those under tree canopy have little to no emergent non-woody vegetation.

Species assemblages of amphibians and reptiles in the Northeast often vary from one pond to the next due to differences in vegetation, latitude, elevation, adjacent habitat type, canopy cover, and past land use. Many amphibians spend their entire lives within a few hundred meters of the wetland where they were born. Frogs generally disperse over longer distances (a kilometer or more) than salamanders (to over 500 meters) but both require appropriate habitat (usually hardwoods in the Northeast) adjacent or near their breeding pools.

Re-colonization of new or restored wetlands is slower for salamanders than for frogs. Once a population has been destroyed, it may take decades for full re-colonization of the original assemblage. This assumes that source populations are near enough to provide immigrants. Forested habitats between wetlands allow dispersal and help populations reduce the risk of complete isolation and extinction from pathogens, loss of genetic diversity, or catastrophic event.

Characteristic species: Jefferson Salamander, Marbled Salamander, Spotted Salamander, Red-spotted Newt, American Toads, Fowler's Toads, chorus frogs, Eastern Gray Treefrog, Wood Frog, Spring Peeper, Spotted Turtle

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Maintain the natural hydroperiod - no drainage, excavations, or diversions in or out. Break tiles if present.
- Allow native characteristic vegetation to flourish to provide physical structure.
- Ensure that the natural integrity of the basin integrity is maintained - no fill or intrusion.
- Remove fill or human debris as necessary to maintain the natural basin.

- Do not stock fish or non-native animals.
- Ensure that water quality is natural and free of sediment, chemicals, and livestock.
- Maintain the natural vegetation around the wetland basin and within the buffer around the core terrestrial zone.
- Remove or control exotic species, both plant and animal.
- Maintain ground cover such as woody debris in the terrestrial buffer zone.
- Minimize barriers to individual movement between wetlands in the landscape such as ditches, curbs, revetments, rip-rap that snags animals, and sunken window sills, and wells for example.
- Add tunnels with directional barriers under roads to allow dispersal and reduce mortality.
- Installation of tunnels (ecopassages) and barriers has been successful in some places to mitigate highway mortality near breeding sites *(see **Roads** section)*.
- Increase awareness of animal crossings and mortality on roads through outreach and education programs.
- Exclude vehicle traffic, including ATVs.
- Minimize chemical use in and around seasonal wetlands. Applications in terrestrial areas may enter wetlands via runoff.
- Remove roads if possible if they are a primary source of mortality. Reroute new ones planned for the area.
- Encourage ecological succession to reach the mature habitat, usually hardwood forest in the Northeast, in the terrestrial buffer zone.
- Restore connectivity between seasonal wetlands.
- Restrict movements by amphibians and reptiles into hazardous areas that may harm these animals (e.g., chemical retention basins).
- Consider constructing artificial wetlands where natural wetlands have been lost or degraded.
- For open wetlands embedded in fire-maintained habitats, permit occasional fires to burn into pond basins when water levels are naturally low.

Importance of Adjacent Uplands
Protect small isolated wetlands while also incorporating adjacent upland habitats and promoting a forested landscape connection to other wetlands. A seasonal wetland without appropriate surrounding upland habitat will lose its amphibian and reptile fauna. *Mark Bailey*

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Identify seasonal wetlands on the property being managed.
- Consider timing of current and planned land use practices to avoid conflicts with animals when they are active.
- Maintain natural habitat connectivity between wetlands (e.g., need 50+ meter corridor to larger habitats and other wetlands).
- Core terrestrial area - maintain canopy cover to encourage cool, moist forest floor
- Encourage conservation tillage if agricultural land use occurs in landscapes containing isolated, seasonal wetlands.
- Encourage silvicultural practices that maintain continuous partial canopy cover in adjacent terrestrial habitat and maintain adequate core wetland buffer zones and corridors.
- Establish buffers in agricultural areas around the core wetland's adjacent terrestrial zone.
- Minimize soil disturbance (i.e. tire ruts, etc.) when using heavy equipment around wetlands.
- Avoid grazing and watering livestock in and near seasonal wetlands.
- Avoid, where possible, using fertilizers, herbicides, and pesticides in or near seasonal wetland. Follow all directions on container labels..
- Locate high-intensity roads, trails, landings, and recreational facilities away from seasonal wetlands and transitional zones into complementary upland habitats.
- Avoid diverting surface water from existing roads or facilities into wetlands.

- Avoid creating permanent farm ponds by altering seasonal wetlands. Create farm ponds elsewhere while retaining the seasonal wetlands.
- Manage beaver colonies to avoid damming of wetlands for conversion to beaver ponds..

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Ditching, deepening, or filling seasonal wetlands.
- Stocking of predatory fish (bass, brem, crappie, catfish, etc.).
- Allowing high-traffic roads to be located near temporary wetlands.
- Using dry pond basins as wildlife food plots or as sites for planting trees.

WEST NILE VIRUS

Health concerns regarding West Nile Virus (WNV) has in some cases resulted in the assumption that many types of standing water, including natural and created wetlands, may be producing dangerous numbers of virus-infected mosquitoes and should be drained, filled, or sprayed to eliminate the possibility of WNV transmission to humans.

Not all mosquitoes transmit WNV, not all mosquitoes feed on humans, and habitats vary for mosquito species. Species of *Aedes* are typically produced in floodwaters in the spring and early summer. Species of *Culex* will deposit eggs in a variety of water-holding containers such as old tires, birdbaths, buckets, wading pools, etc. *Culex pipiens*, the northern house mosquito, is a common household mosquito and the primary vector of WNV. *Culex* larvae thrive in pooled water in areas not normally wet, which do not support their predators.

Mosquitoes are a vital part of wetland food chains, and healthy wetlands have balanced predator-prey relationships that provide natural mosquito control. Salamander larvae are known predators of mosquito larvae. Altered or degraded wetlands often have stagnant water, increased nutrient levels, and fewer natural mosquito predators. Maintaining natural functions of seasonal wetlands and restoring impaired wetlands should be goals of private and public land managers, as well as mosquito control agencies.

For more information:
Centers for Disease Control http://www.cdc.gov/ncidod/dvbid/westnile/index.htm
American Mosquito Control Association: www.mosquito.org
The USDA Regional Pest Management Centers National Pest Alert brochure on WNV
http://www.ncpmc.org/NewsAlerts/westnilevirus.html. *Mark Bailey*

Photos: vernal pool examples, road rut puddle, wood frog, spotted salamander, marbled salamander, Gray Treefrog, egg masses, larvae, degraded or polluted vernal pool, dry vernal pool

B. Permanent wetlands

Permanent wetlands differ from seasonal wetlands primarily because they hold water throughout the year. They include natural lakes, ponds, wet meadows, peat land, swamps, marshes, and impoundments whether made by beavers or humans. We consider permanent wetlands in a different category than streams and rivers because of the lack of running water which provides different physical challenges to amphibians and reptiles. Water depth varies greatly among permanent wetland types. Shallow wetlands allow vegetation to grow throughout much of the basin, whereas deeper ponds and lakes have vegetation usually confined to their perimeters. Deep water can be used by some amphibians and reptiles but not all of them. Thus, the physical structure of permanent wetlands dictates which species may occur in each type.

The Northeast has numerous permanent wetlands, many of which were formed as the glaciers receded over 10,000 years ago. Most are relatively deep and cool with vegetation confined to lake or pond margins.

Characteristic species: American Bullfrog, Green Frog, Mudpuppy, Red-spotted Newt, Painted Turtle, Snapping Turtle, Northern Watersnake

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Maintain water quality and avoid input of sediment, chemicals, and livestock runoff.
- Maintain the natural hydrology of each wetland and prevent unnatural drainage.
- Maintain the native vegetation in throughout shallow wetlands and around the margins of large, deep lakes and pones.
- Maintain the integrity of the wetland basins. Allow no fill, intrusion, drainage, or excavation.
- Avoid introduction of exotic species.
- Maintain habitat structures such as snags, basking logs, rocks, and overhanging vegetation.
- Do not use heavy machinery in wetland basins.
- Avoid clearing or replacing natural vegetation along wetland edges.

- Provide natural buffer zones around or adjacent to wetland edge. Size of buffers can vary but the larger widths of several hundred meters will ensure that populations will remain healthy.

- Maintain natural ground cover (e.g., woody debris) in core habitats and buffer zones.

- Minimize barriers to movement of individuals into and out of permanent wetlands.

- Maintain areas for turtle nesting (e.g., open canopy areas) adjacent or near wetlands.

- Identify and maintain adjacent terrestrial habitat and structural features for summer aestivation and winter hibernacula.

- Remove exotic species from wetlands and in adjacent uplands.

- Remove fill to restore basin and hydrology, fill ditches and break tiles.

- Control or remove exotic species - both plants and animals.

- Add ground cover objects around wetlands.

- Restrict vehicle traffic around wetlands.

- Minimize or avoid chemical use in wetlands and their watersheds.

- Remove roads that act as sources of mortality to animals moving to and from wetlands.

- Evaluate barriers to migration (ditches, curbs, culverts, tunnels) and mitigate or remove them.

- Encourage natural succession patterns.

- Increase awareness of road crossings through outreach and education.

- Restore connectivity between wetlands with natural terrestrial habitats.

- Restrict movement to hazardous wetlands or upland zones (e.g., retention basins
- contaminated by chemicals or radioactivity).

- Restore natural shoreline habitat (e.g., remove retaining walls, sheet piling, rip rap).

- Consider contouring restored wetlands with irregular edges and uneven bottom elevations.

- Address point source and non-point source pollution; remove sources.

- Control and prevent illegal dumping.
- Avoid introduction of game fish. Restricting vehicular public access may discourage unauthorized fish stocking.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Consider timing of current and planned land use practices to avoid harming amphibians and reptiles.
- Maintain connectivity between wetlands with naturally vegetated corridors.
- Avoid complete change in land use - do not develop everything.
- Maintain natural successional patterns in adjacent terrestrial habitats.
- Encourage conservation tillage.
- Establish buffers in agricultural areas around permanent wetlands.
- Livestock in wetlands can be detrimental but in some special situations they can be beneficial, thus evaluate the optimal densities of livestock that minimizes habitat damage.
- Avoid, where possible, using fertilizers, herbicides, and pesticides in adjacent terrestrial areas.
- Limit herbicide use; Follow label directions.
- Avoid yarding or road building adjacent to wetlands.
- Maintain canopy cover as appropriate for the terrestrial habitat.
- Follow existing Best Management Practices for sediment and erosion control; enhance these practices.
- Minimize scarification and rutting of adjacent habitat.
- Avoid high-intensity agricultural, silvicultural, or development-related activities that may cause excessive sedimentation or siltation.

- Minimize or exclude undesirable nutrients or toxins, such as residential and industrial waste.
- Limit recreational access to as few points as is feasible.
- Provide conservation-related educational materials to boaters, skiers, fishermen, and other recreational visitors.
- Avoid creating permanent farm ponds by altering natural wetlands such as swamps and marshes. Create the farm pond elsewhere while retaining natural wetlands.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Clearcutting, mowing, or grazing to water's edge around all or most of the wetland.
- High intensity recreational use, such as swimming, boating, or skiing, over all or most of the impoundment.
- Overstocking or maintaining unusually high densities of predatory game fish.
- Excessive application of fertilizers, herbicides, and pesticides in the watershed.
- Land use activities that add siltation and runoff into permanent wetlands.

Case Study:

Photos: example lakes, ponds, Mudpuppy, newt, bullfrog, painted turtle, snapping turtle, watersnake, degraded or polluted lake or pond

C. Small Streams, Springs and Seepages

Stream habitats in the Northeast include headwater, first and second order streams, as well as the springs and seepages that occur within their often narrow floodplains. They are usually shallow and may be perennial during drought years. Streams in natural landscapes usually have a canopy that is at least a line of trees along the margins. Flow rates depend on elevational gradients, seepage volume production, rain and snow input, and the physical structure of the stream basin and channel. Meandering streams with rocks and debris dams will have slower flows than straightline streams with little structure. Temperatures are usually cooler in higher order and headwater streams than lower order streams. Streams usually have fish populations, many of which are predatory on amphibians and some reptiles. Physical structures in streams such as rocks and debris dams provide microhabitat for salamanders and frogs and their larvae and thus refugia from fish.

Springs and seeps are often integral parts of stream ecosystems. Springs are primary sources of clean water for headwater streams. Seepages are shallow, usually muddy habitats that develop adjacent to springs and have unique floras and faunas, including several salamanders. In part the uniqueness is due to the cool temperatures characteristic of these systems. Threats to small streams, springs, and seepages include clearcutting the forest in the small watershed, construction of dams by beavers with consequent flooding of springs and seeps. Springs and their associated seepages are usually small and vulnerable, but their size also allows for better measures of protection than some of the larger habitats.

Characteristic species: Two-lined Salamander, Northern Red Salamander, Dusky Salamander, Seal Salamander, Spring Salamander, Green Frog, Pickerel Frog

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Avoid clearing or replacing natural vegetation along stream edge.
- Maintain stream floodplains in natural vegetation and avoid alteration.
- Provide upland buffer habitat along the stream's riparian zone to as wide a distance as possible.
- Leave snags and other woody debris in the stream to provide microhabitat.

- Do not remove rocks or boulders.
- Retain natural stream channel undulations, backwater areas, and floodplains. Do not channelize.
- Do not alter spring flows and do not disturb the associated seepage areas.
- Remove exotic vegetation.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Meet or exceed Best Management Practices and Streamside Management Zones standards for stream health.
- Exclude or limit livestock access to stream, spring and seepage habitats..
- Eliminate or minimize agricultural, industrial, forestry-related, and residential toxins, nutrients, sediments, and silt in watersheds containing springs and headwater streams.
- Minimize or control motorized vehicle (including ATV) access to stream channels.
- Avoid, where possible, using fertilizers, herbicides, and pesticides near streams, springs, and seepages.
- Restrict and/or closely regulate collection of salamanders as bait. *(See "Spring Lizards" information box)*
- Evaluate beaver populations and effects in the target area and control their numbers. Protect springs and seepages.

"Spring Lizards"
Harvest of "upstream" salamanders (known locally as spring lizards) for bait may lead to declines in populations. Some states permit fishermen to collect the relatively common Northern Dusky Salamander, and some prohibit collections for bait. Other less common species, however, are virtually indistinguishable from common "duskies" and are therefore incidentally taken as bait, even by the well-intentioned. *Mark Bailey*

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Ditching, deepening, channelization, or filling.
- Allowing excessive residential waste to contaminate ground water supplies that feed springs and headwater streams.
- Unrestricted livestock access for watering.
- Clearcutting the watershed containing small headwater streams, springs, and seepages will cause elevated temperatures and siltation.

Case Study:

Photos: spring and seep, small headwater or first order stream, spring salamander, two-lined salamander, dusky salamander, Northern Red Salamander, pickerel frog, degraded or polluted river or seepage or small stream

D. Rivers

Rivers are the major drainage arteries for watersheds in the Northeast are fed by large streams and smaller rivers. Although some are shallow with rocky bottoms, most have relatively large, deep channels and are steep-sided. Large volumes of water pass through these permanent ecosystems, sometimes at high flow rates, and temperature and turbidity fluctuate according to rain events and release schedules of the major dams. River dams limit movement up- and down-stream as with fish. The amphibians and reptiles that inhabit such dynamic systems are usually able to tolerate these conditions, whereas others find rivers to be barriers to dispersal. Indeed, modern genetics has shown that in some cases rivers delineate species boundaries.

Most rivers in the Northeast contain freshwater throughout most of their courses. Those near the Atlantic Coast, however, experience dramatic fluctuation in salt water concentrations in their tidal zones depending on how much fresh water is being passed through the watershed. Salinity in lower portions of rivers that drain into the Chesapeake Bay, for example, are higher in late summer and fall than in winter and spring when rainfall amounts are lower.

The floodplains of rivers and large streams are used by many species of herps, some on a periodic basis given flood events. Floodplains are integral parts of riverine ecosystems and managers should take into account their role in conservation and management programs on their lands.

Threats to amphibians and reptiles in river systems include mortality from boat propellers, pollution, and introduced predatory fish. Sedimentation is a major problem for many species because of its smothering effects on benthic prey (e.g., mussels) and hiding places. Channelization for increased navigation by large ships and flood control measures all affect river-adapted amphibians and reptiles. Although land owners and managers may have little control over such activities, these aspects of large river management may influence what can or cannot be done on adjacent property.

Rivers are some of our most imperiled and degraded ecosystems. Although threats to river herps include pollution, excessive flow rates, and siltation, conservation efforts aimed at rivers focus primarily on drinking water, recreation, and flood control. Reductions in high-intensity land use within floodplains, such as agriculture and development, would limit the economic impact of naturally occurring floods, improve recreation opportunities, and improve drinking water quality while simultaneously enhancing habitat suitability for herpetofauna and other riverine wildlife.

Characteristic species: Hellbender, Mudpuppy, Common Map Turtle, River Cooter, Snapping Turtle, Spiny Softshell Turtle, Northern Watersnake

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Avoid clearing or replacing natural vegetation along river and stream edge.
- Provide upland buffer habitat along the stream's riparian zone. A minimum of 500 feet is recommended.
- Allow natural movement of sand and gravel: retain sand and gravel bar-related processes by avoiding in-stream mineral extraction, vehicular traffic, and other disruptions to streambeds.
- Do not alter river undulations and backwater areas and do not channelize rivers and streams.
- Allow the natural buildup and movement of woody debris and rocky structure. Do not remove snags and rocks.
- Allow, or where impaired, restore the unimpeded development of native stream bank vegetational composition and structure, bank dynamics, channel meanders, and flood regimes.
- Maintain floodplains in natural vegetation and allow natural flood events to create microhabitats (e.g., pools).
- Avoid thermal alteration and excessive bank erosion by maintaining and where necessary restoring native vegetation composition and structure.
- Exclude point source and non-point source pollution. Do not empty or wash herbicide cans in rivers or streams.
- Limit or avoid the use of rip-rap or other structural modifications that could trap or impede movements of amphibians and reptiles.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Meet or exceed forestry and agricultural Best Management Practices and Streamside Management Zones.
- Avoid, where possible, using fertilizers, herbicides, and pesticides near rivers and streams.
- Minimize activities that alter flow or temperature regimes.
- Exclude or minimize industrial, forestry-related, agricultural, and residential runoff.
- Limit livestock watering activities and/or develop alternative watering sites.

- Stabilize impaired stream banks to allow wildlife access corridors to floodplains and upland nesting sites.
- Restrict public access to nesting sites and other sensitive habitats.
- Restrict recreational access (boat landings, etc.) to as few points as is feasible and away from nesting areas.
- Keep snag removal activities to the minimum necessary for boat traffic.
- Avoid the introduction of non-native game fish and other exotic species.
- Limit excessive harvest and indiscriminant killing of amphibian and reptile species and/or enforce existing regulations more strictly.
- Provide conservation-related educational materials to boaters, fishermen, and other recreational visitors.
- Dispose of dredge spoil to areas that would benefit nesting turtles.
- Roads should be routed to avoid floodplains and nesting areas.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Widespread removal of shade cover and other native vegetation in floodplains and watersheds.
- Channelization and dredging of main river channels and tributaries.
- Ditching to drain wetlands directly into river channels.
- Removal of all snags, debris, and potential nesting sites.

Case Study:

Photos: example rivers (2?), hellbender, watersnake, snapping turtle, map turtle, River Cooter, spiny softshell, degraded or polluted river or stream

E. Estuarine/marine

Estuarine and marine ecosystems are truly dynamic environments. The salt in these waters challenges the physiology of amphibians and reptiles because these vertebrates are usually adapted to fresh water. Wave action, tidal surges, cyclical turnover of salt and fresh water, wind, sand, storms, changing temperatures, and the many predators in these waters make it difficult to live in these places. Estuarine systems include open bays, tidal rivers, and salt marshes which are characterized by salinities that vary monthly, seasonally, and daily when storms occur. Several species of amphibians and reptiles inhabit estuaries because they are able to tolerate salt or brackish water permanently or periodically. Marine systems on the other hand support relatively few reptiles, and nearly all of those are sea turtles. Several snakes swim in the surf occasionally, but there are no marine amphibians due to the high salt content. Reptiles routinely occur in large estuaries like to Chesapeake and Delaware bays. The diamond-backed terrapin is the only true estuarine reptile in the world.

Several species of amphibians and numerous reptiles occur on barrier islands and along oceanic shorelines of the Northeast. Management of these animals in estuarine and marine systems will include considerations of their populations in these waters but also on the land areas adjacent to them. Barrier islands are bordered on the bay side by brackish marshes and intertidal swales and on the ocean side by a sandy shoreline and dunes. These islands and shorelines lacking islands receive periodic overwash that may inundate freshwater ponds or pools. An important characteristic of amphibian and reptile populations in these habitats is that they are dynamic.

Beaches and dunes are critical nesting habitats for the protected sea turtles and entire barrier islands and most dune areas are used extensively by the declining diamond-backed terrapin. Pollution from a variety of sources has killed herps and destroyed nesting beaches in many areas. Such habitats for turtles and their nests are usually primary targets for active management and protection annually during summer months. Causeways across salt marshes are also important habitats because diamond-backed terrapins nest there extensively. Unfortunately, vehicular traffic causes high rates of mortality of the females seeking nesting sites. Management and conservation projects offer challenging opportunities to land managers, biologists, and land owners.

Another challenge is to minimize the loss of individual sea turtles and diamond-backed terrapins from nets, trawls, and crab pots. Although there are laws and regulations that should help this problem, the reality is that these animals are still declining in the Northeast.

Characteristic species: Diamond-backed Terrapin, Kemp's Ridley Sea Turtle, Loggerhead Sea Turtle, Snapping Turtle, Northern Watersnake, Green Treefrog

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Maintain natural shoreline and dune integrity.
- Minimize or eliminate point source and non-point source pollution.
- Exclude and, where necessary, remove exotic reptile species.
- Exclude point source and non-point source pollution.
- Maintain or, where necessary, restore natural shoreline integrity.
- Maintain or restore natural hydrological patterns, including storm over-wash and formation of sand bars by removal of jetties, pilings, and revetments that alter natural sand flow.
- Maintain native submerged native vegetation.
- Exclude and, where necessary, remove non-native invasive plants in marshes and on dunes.
- Exclude pedestrian and motorized vehicle traffic, including boats, jet skis, dune buggies, and ATVs to avoid soil compaction, erosion, and mortality of reptiles like hatchling sea turtles.
- Protect adjacent complementary habitats, like dunes, swales, and maritime forests, to allow for seasonal movement of species.
- Minimize barriers to movements of species that use estuarine and shoreline habitats on a seasonal basis.
- Be aware of potential effects of underwater sound pollution from industrial and military sources and how they may affect reptiles in estuaries.
- Use innovative techniques for insect control (e.g., mosquitoes) and avoid ditching and excessive use of chemicals.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Timing of current and planned activities should avoid nesting periods and hatching periods of turtles.
- Maintaining existing adjacent coastal wetlands that act as buffer for estuarine systems.
- Control subsidized predator populations and their subsidies (e.g., raccoons)
- Limit pedestrian and motorized traffic, including boats, jet skis, dune buggies, and ATVs.
- Where feasible, limit shoreline development.
- Incorporate herpetofauna habitat needs into development plans.
- Increase awareness of traditional reptile crossing areas.
- If human activity is unavoidable during turtle nesting season, install signs around turtle nesting areas to discourage heavy traffic.
- Use oversized culverts to maintain natural salt-water flow patterns.
- Encourage use of turtle-friendly fisheries equipment and excluder devices in crab traps.
- Where feasible, use innovative, non-toxic techniques for mosquito control.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Fishing with nets, trawls, and crab pots without excluder devices or other means of minimizing turtle mortality.
- Vehicular impacts on beaches and dunes during turtle nesting and hatching season.
- Allowing unabated pollution.
- Introducing non-native predators and species that alter natural vegetative communities.

Case Study:

Photos: estuary with bay and marsh, barrier island, Green Treefrog, diamond-backed terrapin, loggerhead sea turtle, northern watersnake, degraded/polluted marsh

F. Hardwood Forests

Much of the Northeast was covered with hardwood forests of various combinations of species, depending on elevation, aspect, and location, before European colonization and wide-scale clearing. Major forest types include oak-hickory, elm-ash-cottonwood, and maple-beech-birch. In some areas, aspen is mixed with birch and pine is interspersed among oaks. Some areas to the southeast in this region support various mixtures of coniferous and broadleaved trees in uplands but sweet gum bald cypress occur in the lowlands and toward the coast.

Hardwood forest trees are deciduous and have extensive root systems. They help to create a three-dimensional forest floor structure of leaves, organically rich soil, and subterranean passageways that supports a diversity of predators and prey, including amphibians and reptiles. Decomposing logs and limbs (downed woody debris) provide crucial microhabitats for many species. Herbaceous vegetation, shrubs, and understory trees add structure to the forest above ground. The soils tend to be relatively moist compared to pine forests that need less moisture. Energy flow through northeastern hardwood is substantial. One salamander alone, the red-backed salamander, plays a crucial role as the energy contained in many northeastern hardwood forests. The biomass (energy in animal tissues per square meter) of a red-backed salamander population in Massachusetts was twice that of all the birds during peak breeding season and about equal to that of all the small mammals. Other species can also reach such high densities in some areas (e.g., salamanders in the Appalachians). Thus, amphibians and many reptiles that act as predators and prey are important players in energy dynamics in mesic upland forests.

The diversity of amphibians and reptiles characteristic of a target management area forest depends on several factors. These include aspect which influences temperature and moisture; elevation and latitude which determine which species occurs there, forest structure, canopy openness or closure, and the history of the landscape. Forest structure and canopy openness varies across the landscape due to tree density, gaps in the forest created by wind-throws, and amount of edge habitat. How the land was used by humans historically affects which species occur there. Severely degraded soils from centuries of intensive agriculture will support fewer species than soils in areas that have largely remained forested. Generally, most amphibians tend to rely on cool, moist habitats, whereas most reptiles need more sunlight and higher temperatures. Thus, a mosaic of microhabitats in a mesic hardwood forest will support a higher diversity of herps than a forest with uniform environmental conditions.

Humans affect mesic hardwood forests in a number of ways that greatly impact amphibians and reptiles. The size of the forest patch, its isolation from other patches, the amount of edge around the patch, water systems in the patch and distance from water sources, tree density, and canopy cover. Fragmentation of forests across the landscape creates a patchwork of habitats of various sizes and degree of isolation. Herp populations must then contend with the many problems associated with small population size, isolation, and susceptibility to disease and catastrophic environmental events. Chemical use for control or elimination of unwanted plants and pests can have a dramatic effect on these animals. Acid precipitation impacts herps on the forest floor and in aquatic systems associated with mesic hardwood forests.

Characteristic species: Red-backed Salamander, Northern Slimy Salamander, Wood Frog, American Toad, Five-lined Skink, Eastern Worm Snake, Eastern Ratsnake, Ring-necked Snake, Eastern Box Turtle

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Avoid fragmenting forests into small fragments with roads, field crops, and other barriers between them.
- Protect unique habitat features within the forest, such as ephemeral wetlands.
- Leave logs, snags, and other woody debris on site; replace as needed.
- Do not clearcut forests; seek other options for forest prescriptions (e.g., single tree removal)
- Ensure that the forest floor is intact and as natural as possible, allow the forest to maintain structure.
- Provide corridors of suitable habitat between forest fragments.
- Minimize or eliminate barriers to dispersal across the landscape between forest fragments.
- Keep deer populations within manageable levels so that they will not destroy forest structure crucial to amphibians and reptiles.
- Mimic natural processes, such as wind throws and fire, as necessary.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Minimize manipulating the soil during forest activities, such as logging (no tillage).

- Minimize scarification and rutting of adjacent habitat.
- Limit use of monoculture stands and even aged timber; maintain habitat and age diversity.
- Maintain canopy cover as appropriate for the habitat.
- Follow existing Best Management Practices for sediment and erosion control; enhance these practices.
- Work with knowledgeable herpetologists to minimize impact on native species through judicious use of shelterwood, group selection, and single tree selection prescriptions.
- Understand effects of forest stand prescriptions and how to minimize their impacts.
- Heavy site preparation may be severe and will harm native species; avoid where possible.
- Limit the construction of new logging roads; return to natural contours and conditions when they are no longer needed.
- Keep deer populations within manageable levels so that they will not destroy forest structure crucial to amphibians and reptiles.
- Avoid using chemicals that will harm herps or their prey. Use Entomophaga spores, for example, to control gypsy moths instead of pesticides.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Clearcutting all hardwood forests on the landscape.
- Maintaining single tree species with the same age structure.
- Creating small fragments so that the environment is all edge; there is no interior forest structure.
- Erecting barriers to amphibian and reptile dispersal between fragments.

Case Study:

Photos: examples, clearcut, other logging method, red-backed salamander, Northern Slimy Salamander, spring peeper, ring-necked snake, black ratsnake, Eastern Worm Snake, box turtle,

G. Spruce/Fir Forests

The primary forest type in northern New England, primarily Maine, and eastern New York is red spruce and balsam fir. This forest dominated the poorly-drained and acidic soils of glacial origin. Cold temperatures and soil conditions allowed this forest to remain relatively intact until recently. In areas with relatively fertile soils, deciduous trees such as yellow birch, red maple, American beech, and sugar maple are interspersed with the spruce and fir. Despite the cold environment and poor soils in some regions, this forest and associated habitats supports as many as 18 amphibians and 16 reptiles.

In the southern portion of the Northeast spruce/fir forests are limited to the highest peaks in the Appalachian Mountains. Canopy trees are often misshapen by high winds. In some cases, canopy trees may be sparse or entirely absent and replaced by heath or grassy balds. Spruce/fir forests in the Appalachians support locally high populations of plethodontid salamanders, several of which are endemic with very restricted ranges.

Amphibians in these habitats use the forest floor cover for foraging, refugia and hibernacula. Some salamanders can reach high densities in the moss and duff layers. Reptiles need gaps and exposure to sun. They are usually associated with rocky areas in this habitat.

Spruce/fir forests are susceptible to insect outbreaks such as the native spruce budworm and the introduced balsam wooly adelgid. Loss of older trees has affected forest age structure and widespread logging for the pulp industry remains a serious threat.

Characteristic species: spotted salamander, four-toed salamander, red-backed salamander, American toad, spring peeper, wood frog, eastern garter snake, red-bellied snake, wood turtle

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Exclude motorized vehicles, including ATVs.
- Maintain and, where necessary, restore native forest cover. Protect stands of older trees, especially old growth stands, from harvest. Allow younger stands to reach maturity.
- Find ways to control threats to existing systems from acid rain, balsam wooly adelgid, and gypsy moths.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Allow dead trees and woody debris to decompose naturally on the ground.
- Limit pedestrian and motorized vehicle access, including ATVs. Stabilize road bands and trails if erosion is a problem.
- Where timber harvest is unavoidable:
    - Limit tree selection to damaged/dying trees
    - Harvest trees that are encroaching on grass or heath balds
    - Avoid soil disturbances associated with heavy equipment
    - Use removal methods that do not disturb the forest floor.
- Minimize fragmentation.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Clearcutting entire forest patches.
- Destroying the forest floor during timbering operations.

Case Study:

Photos: example forest, clearcut or altered forest, four-toed salamander, red-backed salamander, eastern garter snake, red-bellied snake, wood turtle

H. Pine Forests

Parts of the Northeast have xeric (low moisture), well-drained soils that do not support deciduous, broad-leaved trees. Such areas are characterized pine forests. Examples are the pitch pine barrens in Connecticut and New York, the Pine Barrens in New Jersey, and the south-facing slopes in the Blue Ridge and Appalachian mountains. Many of these forests have associated oak trees (e.g., scrub oak) but these tend to be sub-dominant. Naturally occurring pine forests are relatively open with a herbaceous ground cover and shrub layer. Recurring fire is an important component of these habitats that retards hardwood growth and maintains the more tolerant pine species. Fire should be part of the manager's toolbox in this habitat type.

In addition to the naturally occurring pine forests in the Northeast, pine (largely loblolly and Virginia) occurs on former agricultural fields. Stands in the early stages of succession are thick and nearly impenetrable. These areas do not support the diversity of amphibians and reptiles found in natural pine habitats but several species use these successional habitats to varying degrees.

Amphibians and reptiles use the forest floor extensively in pine-dominated habitats. Systems of decaying roots below stumps and underground tunnels derived from mammal tunnels and decaying roots serve as hiding places and hibernacula. Moisture conditions affect activity patterns, with much of the amphibian activity correlated with periods of rainfall. Toads will stay underground for months until the surface is wet. Reptiles are somewhat less limited by moisture and are usually inactive during periods of high temperatures.

Characteristic species: American Toad, Fowler's Toad, Northern Fence Lizard, Copperhead, Timber Rattlesnake, Black Racer

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Avoid fragmenting pine forests into small patches with roads, crops, and other barriers.
- Protect unique habitat features within the forest, such as ephemeral wetlands and streams.
- Leave logs, snags, and other woody debris on site; replace as needed.
- Do not clearcut forests; seek other options for forest prescriptions.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Avoid manipulating the soil during forest activities, such as logging (no tillage).
- Minimize scarification and rutting of adjacent habitat.
- Limit use of monoculture stands and even-aged timber; maintain habitat and age diversity.
- Maintain canopy gaps and downed woody debris.
- Work with knowledgeable herpetologists to minimize impact on native species through judicious use of shelterwood, group selection, and single tree selection prescriptions.
- Understand effects of forest stand prescriptions and how to minimize their impacts.
- Heavy site preparation may be severe and will harm native species; avoid where possible.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Heavy mechanical site preparation (e.g., tilling the soil after burning).
- Heavy use of herbicides (especially aerial applications)
- Maintaining extensive patches of closed-canopy, even-aged pine forest with minimal herbaceous diversity and/or abundance.
- Extensive clearcuts on the landscape (rather than mosaic of smaller clearings).

Case Study:

Photos: example forest, pine plantation monoculture, Fowler's toad, five-lined skink, Northern Fence Lizard, Black Racer

I. Grasslands/old fields

Grass-dominated habitats have increased in the Northeast due to extensive forest clearing and agriculture. Abandoned fields, recent clearcuts, and reclaimed surface mines are quickly colonized by annual and perennial grasses that produce extensive ground cover. Small mammals use this microhabitat extensively and thus attract several species of predatory snakes. There is no canopy, thus high temperatures in warm months limit the occurrence of amphibians. Frogs and some salamanders may be present when there are associated microhabitats such as rock cover, downed woody debris from adjacent forests, ephemeral pools, and streams. Patches of grasslands within extensive forest cover, at high elevations, and at northern latitudes offer open canopy areas where reptiles can achieve temperatures necessary for maintenance and embryonic development.

Natural grasslands in the region include mountain-top balds, cedar glades, and sandy areas and places with thin, rocky, and low nutrient soils within pine savannahs and pine barrens. Fire plays an important role in maintaining these natural systems. Fire frequency regulates the number and density of pine and other fire-tolerant trees in these areas. Natural grasslands are generally rare in the Northeast.

Characteristic species: Black Racer, Eastern Gartersnake, Eastern Milksnake, Smooth Greensnake, Eastern Box Turtle

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Maintain the open nature of the habitat; promote a spatially-variable canopy cover appropriate for the area.
- Protect wetlands within grasslands from human encroachment.
- Control livestock access; avoid excess grazing.
- Promote diverse, native grasses and forbs, and when necessary remove exotic plant species, woody encroachment, and woody succession.
- Avoid use of non-native vegetation.

- Prohibit off-road vehicle access.
- Maintain and, where necessary, restore natural fire frequency, intensity, and seasonality, including landscape-scale fire in surrounding, complementary habitats where appropriate.
- Maintain or restore connectivity between similar habitats and between complementary but dissimilar habitats, especially via landscape-scale fire.
- Where fire is not possible, consider limited, controlled grazing, especially by softer-hoofed herbivores such as goats.
- Maintain or restore natural hydrology in wet grasslands.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Where mowing cannot be avoided or where haying is a goal:
    - mow when reptiles and amphibians are least active (preferably prior to emergence from hibernation).
    - mow at high blade settings (8 inches or greater).
    - mow no more than once per year.
- Where grazing is a goal, rotate livestock frequently to prevent over-grazing.
- Limit pedestrian and motorized vehicle traffic, including dirt bikes and ATVs.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Ecological succession to hardwoods and full canopy.
- Mowing at a low blade height and high frequencies.
- Excessive off-road vehicle use.

Case Study:

Photos: example old field, natural grassland, black racer, smooth Greensnake, Black Racer, Gartersnake, Box Turtle

J. Rock outcrops/talus

Exposed rock outcrops and talus slopes are relatively small habitats embedded within larger ecosystems such as hardwood forests. Most in the Northeast are usually located in mountainous or hilly areas on south-facing slopes. They are dry, sparsely vegetated, with little to no soil and sparse to no canopy, and have an abundance of hiding places among the rocks and crevices. Gradients between open sun, shade, and moisture regimes are often abrupt. Glades, cliffs, talus, quarries, rock slides, and ledges are examples of this habitat type. Reptiles are more characteristic of these habitats than amphibians. Several snakes, notably timber rattlesnakes and copperheads, use such habitats for basking sites, birthing rookeries, and winter hibernacula. Except for some species like the northern fence lizard, use of this habitat type is usually seasonal. Several species of salamanders and frogs occupy talus slopes and glades that are on north-facing slopes. Occupancy by these herps tends to be year-round.

Rock outcrops, ledges, talus, and rocky glades are subject to a variety of threats, including human use from various forms of recreation. Some areas known for their numbers of snakes attract some people who seek to eliminate them. Fire is usually a natural form of maintenance but exclusion of fire causes overgrowth of vegetation, including canopy, that destroys the thermal characteristics of these habitats.

Characteristic species: Northern Fence Lizard, Black Racer, Copperhead, Eastern Milksnake, Timber Rattlesnake on south-facing slopes; Red-backed Salamanders, Northern Red Salamanders, Pickerel Frogs on north-facing slopes.

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Exclude heavy human use such as ATV access especially in the vicinity of sensitive habitat elements such as nesting, breeding, or denning areas, as well as gradients between rocky areas and surrounding, complementary habitats.
- Exclude logging, grazing, development, and other erosion-generating activities uphill from biologically significant sites.
- Maintain biologically significant areas, including reptile den sites and significant salamander occurrences.
- Minimize publicity of biologically significant areas to prevent poaching or indiscriminate killing.

- Protect surrounding complementary habitats and gradients between habitats to allow for unimpeded season dispersal of reptiles and amphibians.
- Where appropriate, maintain or restore natural fire frequency, especially in surrounding, complementary habitats.
- Exclude or remove exotic plant species.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Limit rock climbing and other recreational activities to areas well away from biologically significant areas.
- Limit motorized vehicles, including dirt bikes and ATVs, to areas well away from biologically significant sites and gradients between rocky areas and surrounding, complementary habitats.
- Where roads, trails, grazing, or logging are unavoidable, use silt fencing or other means to minimize erosion and soil disturbances uphill from biologically significant sites.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Allowing these habitats to be overgrown so that sunlight cannot reach rock surfaces.
- Extensive recreational use.
- Clearcutting large areas around these habitats.
- Destruction of snake den sites.

Case Study:

Photos: example photos, fence lizard, timber rattlesnake, copperhead, milksnake, example salamander

K. Caves and Karst Systems

Despite the fact that they are made of rocks, caves and karst habitats are fragile systems. They are specialized habitats that have unique air flow patterns and relative humidity levels and other microhabitat characteristics that remain stable over long periods of time, thousands of years. They are sensitive to surface activities that cause input of water, pollution, waste of various sorts (e.g., garbage). Human recreational use can easily disrupt the stable environmental balance and physical structure of these habitats, and thus harm the often unique animal inhabitants in the process. Caves and karst systems occur in the Northeast primarily in the Blue Ridge and Appalachian Mountain regions but also well into the Adirondacks. Some are well known and operated commercially (e.g. Luray Caverns in Virginia) and others are well-kept secrets. Many are protected by land managers and private land owners. Abandoned mine shafts can sometime function much like caves and be used by some species of herps.

Some salamanders are especially suited for the dark reaches of caves and karst systems. One of these in the Northeast, the West Virginia spring salamander, is known from only a stream in one cave. Long-tailed salamanders are well-known cave inhabitants. The twilight zone of caves is used by several species of reptiles and frogs and less specialized salamanders. Many of these herps use the mouths of caves and the surrounding habitat extensively. Some reptiles use caves and karst systems for winter hibernacula.

Characteristic species: Long-tailed Salamander, Cave Salamander, Green Salamander, Pickerel Frog, Black Ratsnake, Eastern Gartersnake.

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Each cave is unique, an irreplaceable creation that should be protected from damage.
- Protect the water supply feeding the cave; help safeguard its water quality.
- Restrict human use to areas of least sensitivity or prevent human use except for specialized reasons.
- Keep livestock and off-road vehicles out of cave openings and water sources.
- Prevent overgrowth of karst and cave mouths by shrubs and trees, but also prevent erosion from higher elevation areas that might fill spaces among rocks.

- Protect airflow regimes and prevent excessive sediment by excluding soil disturbances, erosion, and vent blockage throughout the recharge area.
- Stabilize entrance to mines to protect herpetofauna access and air flow.
- Maintain or restore forested buffers or, preferably, landscape-scale forest matrices around cave openings.
- Exclude point-source and non-point source water pollution throughout the surface recharge area. Prohibit dumping, including trash & organic debris.
- Maintain or restore natural surface hydrology throughout the recharge area.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Where access is permitted, limit to times of low seasonal fauna activity/presence.
- If timber harvest in surrounding forests is unavoidable, consider selective cuts or a mosaic of small clearcuts.
- If erosion and/or pollution generating activities are unavoidable in the recharge area, meet or exceed Best Management Practices.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Unrestricted human recreation or visitor use.
- Input of pollution from the surface recharge area.
- Sealing of cave entrances.
- Altering openings or other structures that would change air flow patterns and relative humidity levels.

Case Study:

Photos: example cave, Long-tailed Salamander, Cave Salamander, Green Salamander, Pickerel Frog, Eastern Gartersnake.

L. Agricultural Lands

Some 22% or more of the landscape in the Northeast is used for agricultural purposes. The amount of land varies among states but most have experienced large declines in natural habitats for this single endeavor. Agricultural landscapes are actually mosaics of cultivated crops, pasture, orchards, hedge rows, farm ponds, swales/ditches, out buildings/barns, rock walls, and abandoned fields. Fragments of forests remain in many areas but they are subject to severe edge effect. Degraded stream corridors, pollution from chemical runoff and animal wastes, introduced species, and subsidized species typify agricultural regions. Such landscapes do not support the natural herpetofaunal diversity that would otherwise occur there. Despite these facts, some herps still occur in forest patches, vernal pools, ponds, streams, vegetated riparian zones, wooded slopes, ditches, and vegetated fencerows.

Amphibians and reptiles in agricultural landscapes face several major threats, including death from mowing machinery, vehicular traffic on roads, and chemicals (e.g., direct or indirect accumulation of pesticides and herbicides). Maintenance of viable populations requires corridors of appropriate habitat, reduction of the barriers to dispersal, and minimization of the threats. Management of habitats that contain these animals would go a long way to ensure that they will remain integral parts of the landscape and the farming culture in the Northeast. Agricultural lands are not likely to be allowed to succeed to natural climax ecosystems. The increasing modern trend instead is to convert these lands to urban and suburban areas with even less habitat for amphibians and reptiles.

Characteristic species: Fowler's Toad, American Bullfrog, Eastern Box Turtle, Painted Turtle, Five-lined Skink, Northern Fence Lizard, Black Racer, Black Ratsnake, Northern Watersnake

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Add buffers along wetlands and streams.
- Develop corridors between habitat fragments.
- Avoid mowing shorelines and drainage ditches mid-Spring to mid-Fall.
- Reduce livestock access to streams and wetlands; avoid overgrazing.
- Reduce use herbicides and pesticides; use Integrated Pest Management procedures.

- Restore wetland complexes.
- Use intensive pasture management (localize and reduce number of fields used).
- Reduce erosion from livestock and tillage.
- Learn effective nutrient management (timing, amounts, mechanics of spreading).
- Maintain canopy in forested landscapes that are used for other purposes.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Protect and buffer any remaining natural areas.
- Develop naturally vegetated corridors between habitat fragments.
- Consider restoring natural hydrology to drained and altered wetlands.
- Avoid mowing wetlands, shorelines, and ditches mid-spring through mid-fall. When mowing fields, raise deck height to at least 8 inches.
- Avoid overgrazing and keep livestock out of wetlands.
- Follow pesticide/fertilizer label directions very carefully; use sparingly and precisely where needed.

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Careless use of pesticides and herbicides in a manner inconsistent with labeling.
- Removal of fencerows, filling/ditching wetlands, and similar practices to maximize crop production at the expense of wildlife habitat.

Case Study:

Photos: agricultural landscape, example habitats within such, Fowler's Toad, American Bullfrog, Eastern Box Turtle, Painted Turtle, Five-lined Skink, Black Racer, Black Ratsnake, Northern Watersnake

M. Urban/Suburban Systems

Urban and suburban areas are characterized by a mosaic of landscapes that are completely unsuitable for amphibians and reptiles and some that support populations of tolerant species. Habitat loss and alteration typify urban areas. Patches of habitat suitable for some species persist, however, even amongst the commercial, industrial, and housing complexes. The urban landscape comprises over 5 million hectares in the Northeast and is thus a major habitat type in this region.

The ratio of natural habitat to altered habitat in the landscape matrix is low, indicating that dispersal between habitat patches is difficult to impossible because of the many barriers and sources of mortality. Barriers include storm drains, curbs, fences and other barricades, buildings, channelized streams, and hot asphalt. High density of roads in urban areas along with high traffic volume allow few animals to cross over. Dogs, cats, crows, blue jays, raccoons, opossums and other subsidized predators that thrive in urban systems are other major sources of mortality. Thus, the gauntlets through which an individual amphibian or reptile must pass while dispersing create major challenges to exchange among populations. Most populations in isolated habitat patches, therefore, are likely to be small, have no immigrants to provide new genetic material, and are subject to the many problems of small population size.

Patches of habitat in urban areas include parks, woodlots, backyard habitats and ponds, wetlands of varying quality, streams with narrow wooded buffer zones, golf courses, and plant nurseries. Some species persist for many years in these habitats. Urban habitat patches offer opportunities for enhancement, restoration, and creation that would greatly benefit some amphibians and reptiles.

It is likely that use of the landscape in urban and suburban areas will allow few opportunities to manage habitat solely for amphibians and reptiles. Most land use is for human living and working space and their infrastructure. It is possible, however, that some areas containing suitable habitat and stream and river corridors can be managed for these animals.

Characteristic species: Two-lined Salamander, Spring Peeper, American Toad, Fowler's Toad, Eastern Gartersnake, Northern Brown snake, American Bullfrog, Gray Treefrog

MANAGEMENT GUIDELINES

IDEAL

When benefiting amphibians and reptiles is a primary objective:

- Protect and buffer special natural areas, such as isolated wetlands, vernal pools, forested riverine floodplains.

- Maintain and develop corridors between habitat fragments
- Historical water regimes should be maintained in streams and rivers.
- Maintain vernal pools and other small wetlands in riparian zones and elsewhere.
- Prevent the introduction of and minimize use non-native vegetation
- Prevent the introduction of non-native species, especially those that would unnatural sources of mortality.
- Assess the impact and consider control of subsidized native predators.

COMPATIBLE

When benefiting amphibians and reptiles is secondary to other management objectives:

- Identify and protect existing special habitat features such as streams, wetlands, and rock outcroppings.
- Consider protection of wetlands, stream corridors, and representative terrestrial habitats during the planning process before development permits are issued.
- Protect and maintain riparian and wetland areas, including the maintenance of pre-development hydrology (depth, duration, and frequency of flooding) of streams and wetlands.
- Open dialogs among land owners, county and town planners, ecologists, and developers before it is too late in the planning process.
- Encourage developers to design their projects around natural areas to minimize habitat fragmentation, protect stream corridors, and maintain natural vegetation.
- Install a garden pool.
- Landscape with native species. Prevent the introduction and spread of exotic plants and animals.
- Spay and neuter cats and dogs, and keep them indoors.
- Encourage and support public education about the aesthetic, ecological, and spiritual value of wildlife.

- Limit the use of fertilizers, herbicides, and pesticides, especially on golf courses and lawns.
- Do not introduce species, like fire ants, in landscape plants and other materials.
- Consider rerouting planned or existing roads around, instead of through, sensitive natural areas.
- Identify and/or create core breeding habitats with associated upland habitat and corridors to connect them. Include road crossings (culverts) where feasible. Use signs in the vicinity of known migration routes.

The Most Environmentally-friendly Pesticide?
Anyone who owns a flower bed knows that slugs can seriously damage ornamental foliage. Although there are numbers of pesticides on the market that target slugs, they often raise questions: How safe are they? Why do the slugs keep coming back?

Gartersnakes, Northern Brownsnakes, Red-bellied Snakes, and Box Turtles love to eat slugs (and other pests) and have adapted to urban life in many areas. Unlike most pesticides, snakes and turtles are guaranteed 100% environmentally safe and can find and eat source populations of slugs in places where chemicals can't (foundations, burrows, stone walls, etc). *Mark Bailey*

Examples of INCOMPATIBLE management

Amphibian and reptile populations may not remain viable under these land use regimes:

- Complete removal of native vegetation to the margins of wetlands and streams.
- Establishment of wooded buffer zones less than 50 feet in width along streams.
- Stream channelization and routing streams through concrete corridors.
- Introduction of non-native predators and pests.
- Allowing feral cat colonies to become established.

Case Study:

Photos: examples of urban system, example of habitat that contain herps, Two-lined Salamander, Spring Peeper, American Toad, Northern Brown snake, Green Frog,

The Management Plan

An important first step in managing habitats and the landscape for amphibians and reptiles, no matter what the designated land use may be, is to develop a management plan. Know what you have to work with and what current conditions are before initiating changes. Evaluation of existing conditions includes an inventory of existing habitat types, maps of their relative locations and sizes, and identification of landscape features and use that may influence each habitat in some way. Once such information is organized and on paper (or computer), then land owners and managers can identify features of habitats that need alteration or restoration in ways to benefit amphibians and reptiles. If other land uses are the primary focus, then one can identify ways to minimize impacts on these animals in the habitats with which one has to work.

Management plans should be designed to be dynamic instruments. They allow you to visualize what the impacts of a project might be, how one can make beneficial changes, and determine how to change the action if it is determined the first approach does not achieve the desired effect.

Land owners and managers may benefit from the insights of an experienced local or regional biologist that understands the ecology, natural history, and behavior of amphibians and reptiles. Ecologists and land managers who know the local ecosystems and habitats may also be valuable sources of information and insights. The Soil and Water Conservation Service (SWCD) and the National Resources Conservation Service (NRCS) have district offices in many areas in the Northeast, typically in every county. The list of Resources in this document provides sources you can contact to obtain useful information on a variety of topics pertaining to habitat and landscape management.

Acknowledgments

Appendix A - Amphibians and Reptiles of the Northeast by State and Habitat Type

Species	Common Name	CT	DE	ME	MD	MA	NH	NJ	NY	PA	RI	VT	VA	WV	Seasonal Wetlands	Permanent Wetlands	Streams	Rivers	Estuarine / Marine	Spruce-Fir Forest	Mesic Upland Forest	Xeric Upland Forest	Grasslands / Old fields	Rock Outcrops / Talus	Caves / Karst	Agricultural	Urban
AMPHIBIA																											
Bufo americanus	American Toad	N	N	N	N	N	N	N	N	N	N	N	N	N	P	P				P	P	P	P				
Bufo fowleri	Fowler's Toad	N	N		N	N	N	N	N	N	N	N	N	N	P	P						P					
Bufo quercicus	Oak Toad												N		P	P						P					
Bufo terrestris	Southern Toad												N		P	P											
Acris crepitans	Cricket Frog		N		N			N	N	N			N	N		P					P		M			M	
Acris gryllus	Coastal Plain Cricket Frog												N			P											
Hyla andersonii	Pine Barrens Treefrog							N								P											
Hyla chrysoscelis	Cope's Gray Treefrog		N		N			N					N	N		P											
Hyla cinerea	Green Treefrog		N		N								N			P											
Hyla femoralis	Pine Woods Treefrog												N			P											
Hyla gratiosa	Barking Treefrog		N		N								N			P											
Hyla squirella	Squirrel Treefrog												N			P											
Hyla versicolor	Gray Treefrog	N	N	N	N	N	N	N	N	N	N	N	N	N		P					P						
Pseudacris brachyphona	Mountain Chorus Frog				N					N			N	N		P											
Pseudacris brimleyi	Brimley's Chorus Frog												N			P											
Pseudacris crucifer	Spring Peeper	N	N	N	N	N	N	N	N	N	N	N	N	N		P					P						
Pseudacris feriarum	Southeastern Chorus Frog		N		N			N		N			N	N		P											
Pseudacris ocularis	Little Grass Frog												N			P											
Pseudacris triseriata	Western Chorus Frog								N	N		N				P					P						
Scaphiopus holbrookii	Eastern Spadefoot	N	N		N	N		N	N	N	N		N	N	P							P					
Rana catesbeiana	American Bullfrog	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P						S			M	M
Rana clamitans	Green Frog	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P						S			M	M
Rana palustris	Pickerel Frog	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P						S				
Rana pipiens	Northern Leopard Frog	N		N	I	N	N		N	N	N	N		N		P	P						P				
Rana septentrionalis	Mink Frog			N			N		N			N				P											
Rana sphenocephala	Southern Leopard Frog		N		N			N	N	N			N			P											
Rana sylvatica	Wood Frog	N	N	N	N	N	N	N	N	N	N	N	N	N	P						P						
Rana virgatipes	Carpenter Frog		N		N			N					N		P												
Gastrophryne carolinensis	Eastern Narrow-mouthed Toad				N			I					N		P												
Ambystoma barbouri	Streamside Salamander													N	P												
Ambystoma jeffersonianum	Jefferson Salamander	N			N	N	N	N	N	N		N	N	N	P		M				P	P	S				
Ambystoma laterale	Blue-spotted Salamander	N		N		N	N	N	N			N			P		M				P	P	S				
Ambystoma mabeei	Mabee's Salamander												N		P						P						
Ambystoma maculatum	Spotted Salamander	N	N	N	N	N	N	N	N	N	N	N	N	N	P	S	M				P	P	S				
Ambystoma opacum	Marbled Salamander	N	N		N	N	N	N	N	N	N	N	N	N	P						P	P					

Species	Common Name	CT	DE	ME	MD	MA	NH	NJ	NY	PA	RI	VT	VA	WV	Seasonal Wetlands	Permanent Wetlands	Streams	Rivers	Estuarine / Marine	Spruce-Fir Forest	Mesic Upland Forest	Xeric Upland Forest	Grasslands / Old fields	Rock Outcrops / Talus	Caves / Karst	Agricultural	Urban
Ambystoma talpoideum	Mole Salamander												N		P						P						
Ambystoma texanum	Small-mouthed Salamander													N	P						P						
Ambystoma tigrinum	Tiger Salamander		N		N			N	N				N		P	S						P	S				
Aneides aeneus	Green Salamander				N					N			N	N			P				P						
Desmognathus auriculatus	Southern Dusky Salamander												N				P				P						
Desmognathus fuscus	Northern Dusky Salamander	N	N	N	N	N	N	N	N	N	N	N	N	N			P				P						
Desmognathus marmoratus	Shovel-nosed Salamander												N				P				P						
Desmognathus monticola	Seal Salamander				N					N			N	N			P				P						
Desmognathus ochrophaeus	Allegheny Mountain Dusky Salamander				N			N	N	N		N	N	N			P				P						
Desmognathus orestes	Blue Ridge Dusky Salamander												N				P				P						
Desmognathus quadramaculatus	Black-bellied Salamander												N	N			P				P						
Desmognathus welteri	Black Mountain Salamander												N	N			P				P						
Desmognathus wrighti	Pygmy Salamander												N				P				P						
Eurycea bislineata	Northern Two-lined Salamander	N	N	N	N	N	N	N	N	N	N	N	N	N			P			S	P						
Eurycea cirrigera	Southern Two-lined Salamander												N	N			P				P						
Eurycea guttolineata	Three-lined Salamander												N				P				P						
Eurycea longicauda	Long-tailed Salamander		N		N			N	N	N			N	N			P				P				P		
Eurycea lucifuga	Cave Salamander												N	N			P				P				P		
Eurycea wilderae	Blue Ridge Two-lined Salamander												N				P				P						
Gyrinophilus porphyriticus	Spring Salamander	N		N	N	N	N	N	N	N	N	N	N	N			P				P						
Gyrinophilus subterraneus	West Virginia Spring Salamander													N			P				P						
Hemidactylium scutatum	Four-toed Salamander	N	N	N	N	N	N	N	N	N	N	N	N	N							P						
Plethodon chlorobryonis	Atlantic Coast Slimy Salamander												N								P						
Plethodon cinereus	Eastern Red-backed Salamander	N	N	N	N	N	N	N	N	N	N	N	N	N						S	P						
Plethodon cylindraceus	White-spotted Slimy Salamander												N	N							P						
Plethodon electromorphus	Northern Ravine Salamander													N							P						
Plethodon glutinosus	Northern Slimy Salamander	N			N		N	N	N	N			N	N							P						
Plethodon hoffmani	Valley and Ridge Salamander				N					N			N	N							P						
Plethodon hubrichti	Peaks of Otter Salamander												N								P						
Plethodon jordani	Jordan's Salamander												N								P						
Plethodon kentucki	Cumberland Plateau Salamander												N	N							P						
Plethodon nettingi	Cheat Mountain Salamander													N							P						
Plethodon punctatus	Cow Knob Salamander												N	N							P						
Plethodon richmondi	Southern Ravine Salamander									N			N	N							P						
Plethodon shenandoah	Shenandoah Salamander												N								P						
Plethodon ventralis	Southern Zigzag Salamander												N								P						

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Plethodon virginia	Shenandoah Mountain Salamander												N	N							P						
Plethodon wehrlei	Wehrle's Salamander				N				N	N			N	N							P						
Plethodon welleri	Weller's Salamander												N								P						
Plethodon yonahlossee	Yonahlossee Salamander												N								P						
Pseudotriton montanus	Mud Salamander		N		N			N		N			N	N			P										
Pseudotriton ruber	Northern Red Salamander		N		N			N	N	N			N	N			P			P							
Stereochilus marginatus	Many-lined Salamander												N			P	P			P							
Cryptobranchus alleganiensis	Hellbender				N				N	N			N	N			P	P									
Siren Intermedia	Lesser Siren												N			P	P										
Siren lacertina	Greater Siren				X								N			P	P	P									
Amphiuma means	Two-toed Amphiuma												N			P	P										
Necturus maculosus	Mudpuppy	N		I	X	I	N		N	N	N	N	N	N			P	P									
Necturus punctatus	Dwarf Waterdog												N				P	P									
Notophthalmus v. viridescens	Red-spotted Newt	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P	P		P	P	P	S				
REPTILIA																											
Caretta caretta	Loggerhead Seaturtle	N	N	N	N	N	N	N	N		N		N						P								
Chelonia mydas	Green Seaturtle	N	N		N	N		N	N		N		N						P								
Eretmochelys imbricata	Hawksbill Seaturtle		N		N	N		N	X		N		N						P								
Lepidochelys kempii	Kemp's Ridley Seaturtle	N	N	N	N	N		N	N		N		N						P								
Dermochelys coriacea	Leatherback Seaturtle	N	N	N	N	N		N	N		N		N						P								
Chelydra serpentina	Snapping Turtle	N	N	N	N	N	N	N	N	N	N	N	N	N					M								
Chrysemys picta	Painted Turtle	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P	P					P				
Clemmys guttata	Spotted Turtle	N	N	N	N	N	N	N	N	N	N	N	N	N	P	P	S										
Clemmys insculpta	Wood Turtle	N		N	N	N	N	N	N	N	N	N	N	N		P	P	P			P		P			S	
Clemmys muhlenbergii	Bog Turtle	N	N		N	N		N	N	N			N			P											
Deirochelys reticularia	Chicken Turtle												N					P									
Emydoidea blandingii	Blanding's Turtle			N		N	N		N	N						P		P			P	P	P			S	
Graptemys geographica	Northern Map Turtle				N			N	N	N		N	N	N				P									
Graptemys ouachitensis	Ouachita Map Turtle													N				P									
Malaclemys terrapin	Diamond-backed Terrapin	N	N		N	N		N	N		N		N						P				P				
Pseudemys concinna	River Cooter												N	N				P									
Pseudemys rubriventris	Northern Red-bellied Cooter		N		N	N		N	I	N			N	N				P									
Terrapene carolina	Eastern Box Turtle	N	N	N	N	N	N	N	N	N	N		N	N							P	P	P				
Trachemys scripta	Pond Slider		I		I	I		I	I	I	I		N	N		P		P									
Kinosternon subrubrum	Eastern Mud Turtle		N		N			N	N	N			N			P						P	P				
Kinosternon bauri	Striped Mud Turtle												N			P	P										

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Sternotherus minor	Loggerhead Musk Turtle												N				P										
Sternotherus odoratus	Stinkpot	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P	P				P					
Apalone mutica	Smooth Softshell									N				N				P									
Apalone spinifera	Spiny Softshell				N			I	N	N		N	N	N				P									
Ophisaurus attenuatus	Slender Glass-lizard												N									P	P				
Ophisaurus ventralis	Eastern Glass-lizard												N			P						P	P				
Podarcis sicula	Italian Wall-lizard								I																		P
Sceloporus undulatus	Fence-lizard		N		N			N	N	N			N	N							P	P		P			
Eumeces anthracinus	Coal Skink				N				N	N			N	N		P					P			P			
Eumeces fasciatus	Common Five-lined Skink	N	N		N	X		N	N	N		N	N	N							S	P		P			
Eumeces inexpectatus	Southeastern Five-lined Skink												N									P	P				
Eumeces laticeps	Broad-headed Skink		N		N					N			N	N		P					P		P				P
Scincella lateralis	Little Brown Skink		N		N			N					N	N								P	P				
Cnemidophorus sexlineatus	Six-lined Racerunner				N								N	N								P	P	P			
Carphophis amoenus	Eastern Wormsnake	N	N		N	N		N	N	N	N		N	N								P					
Cemophora coccinea	Scarletsnake		N		N			N					N									P					
Clonophis kirtlandii	Kirtland's Snake									N						P					P		P				P
Coluber constrictor	Eastern Racer	N	N	N	N	N	N	N	N	N	N	N	N	N							P	P	P				
Diadophis punctatus	Ring-necked Snake	N	N	N	N	N	N	N	N	N	N	N	N	N							P		P				
Elaphe guttata	Cornsnake		N		N			N					N	N								P					
Elaphe obsoleta	Eastern Ratsnake	N	N		N	N		N	N	N	N	N	N	N							P	P		P			
Farancia abacura	Red-bellied Mudsnake												N			P	P										
Farancia erytrogramma	Rainbow Snake				N								N			P	P										
Heterodon platirhinos	Eastern Hog-nosed Snake	N	N		N	N	N	N	N	N	N		N	N								P	P				
Lampropeltis calligaster	Yellow-bellied Kingsnake				N								N										P				
Lampropeltis getula	Common Kingsnake		N		N			N		N			N	N		P	P					P					
Lampropeltis t. triangulum	Eastern Milksnake	N	N	N	N	N	N	N	N	N	N	N	N	N							P		P			P	
Nerodia erythrogaster	Plain-bellied Watersnake		N		N								N			P	P	P									
Nerodia sipedon	Northern Watersnake	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P	P									
Nerodia taxispilota	Brown Watersnake												N			P	P										
Opheodrys aestivus	Rough Greensnake		N		N			N		N			N	N		P	P	P					S				
Opheodrys vernalis	Smooth Greensnake	N		N	N	N	N	N	N	N	N	N	N	N							P	P	P				
Pituophis melanoleucus	Pinesnake				X			N					N	N								P					
Regina rigida	Glossy Crayfish Snake												N				P										
Regina septemvittata	Queen Snake		N		N			N	N	N			N	N			P										
Storeria dekayi	DeKay's Brownsnake	N	N	N	N	N	N	N	N	N	N	N	N	N							P		P				

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Storeria occipitomaculata	Red-bellied Snake	N	N	N	N	N	N	N	N	N	N	N	N	N							P		P				
Tantilla coronata	Southeastern Crowned Snake												N			P					P	P	P				P
Thamnophis brachystoma	Short-headed Gartersnake								N	N											P		P				
Thamnophis sauritus	Eastern Ribbonsnake	N	N	N	N	N	N	N	N	N	N	N	N	N		P					P	P					
Thamnophis sirtalis	Common Gartersnake	N	N	N	N	N	N	N	N	N	N	N	N	N		P	P				P	P	P			P	P
Virginia striatula	Rough Earthsnake												N								P		P				
Virginia valeriae	Smooth Earthsnake		N		N			N		N			N	N							P		P				
Ramphotyphlops braminus	Brahminy Blind Snake					I					?																P
Agkistrodon contortrix	Copperhead		N																		P						
Agkistrodon piscivorus	Cottonmouth												N			P	P	P									
Crotalus horridus	Timber Rattlesnake	N		X	N	N	N	N	N	N	X	N	N	N							P	P	S	P			
Sistrurus catenatus	Massasauga								N	N						P							S			S	
Distribution codes	**Habitat codes**																										
N = Native	**P = Primary**																										
I = Introduced	**S = Suitable**																										
X = Extirpated	**M = Marginal**																										

Appendix B - Resources

Suggested reading for managers

Calhoun, A.J.K. and M.W. Klemens. 2002. Best Development Practices, Conserving Pool-breeding amphibians in residential and commercial developments in the northeastern United States. MCA Technical Paper No. 5, Metropolitan Conservation Alliance, Wildlife Conservation Society, Bronx, NY. 57 pp.

Hunter, M.L., Jr. (editor). 1999. Maintaining Biodiversity in Forest Ecosystems. Cambridge University Press, New York, NY. 698 pp.

Lists of organizations and agencies

NRCS

State sources --

Web sites

EPA

MCA

NRCS

USFWS

Literature Sources on Amphibians and Reptiles

Conant, R. and J.T. Collins. 1998. A Field Guide to Reptiles and Amphibians Eastern and Central North America. 3rd expanded edition. Houghton Mifflin Co., Boston, MA. 616 pp.

Kenney, L.P., and M.R. Burne. 2000. A Field Guide to the animals of Vernal Pools. Massachusetts Div. Fisheries & Wildlife., Westborough, MA. 73 pp. (www.state.ma.us/dfwele/dfw/dfwnhes.htm)

Schneider, R.L., M.E. Kransy, and S.J. Morreale. 2001. Hands-On Herpetology, Exploring Ecology and Conservation. National Science Teachers Association Press, Arlington, VA. 145 pp.